Geopositional Accuracy Validation of Orthorectified Landsat TM Imagery: South Africa

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Scope of Work

This report provides results of an independent assessment of the geopositional accuracy of the Earth Satellite (EarthSat) Corporation's GeoCover™ orthorectified Landsat Thematic Mapper (TM) imagery over South Africa. This imagery was purchased through NASA's Earth Science Enterprise (ESE) Scientific Data Purchase (SDP) program.

Background

The EarthSat data procured through the SDP was orthorectified using a small set of scenes within a large geographic region, or block. Each of these scenes contained government provided ground control coordinates. A geometric model of the block was created based on the controlled scenes. This model was then applied to the rest of the scenes in the block.

Approach

The orthorectified Landsat TM imagery's geopositional accuracy was estimated using a standard procedure that utilizes geodetic control points provided by the U.S. government. The approach was to use a small sample of independently controlled scenes to estimate the horizontal geopositional accuracy of the orthorectified products and to compare that estimate to the geopositional accuracy specified by NASA contract NAS13-98046 with the Earth Satellite Corporation. The contract specifies that the orthorectified TM product shall have a geopositional Root Mean Square Error (RMSE) accuracy of 50 meters.

Dataset

Six Landsat TM scenes over the South Africa region were used in this activity. The selection of scenes used for the validation was dependent upon the availability of geodetic ground control points. Appendix A contains a map showing the location of the scenes used for validation in relation to the entire block processed by Earth Satellite Corporation. Earth Science Applications (ESA) Directorate personnel imported each orthorectified TM scene from GeoTIFF format to ERDAS IMAGINE format. Analysts used ERDAS IMAGINE software to analyze each 7-band scene.

Geodetic Control Reference Data

The U.S. government provided a set of geodetic control points for use in this assessment. This ground control information was available only for specific parts of the globe. Of the available points, selected points were omitted as described in the Procedure section below. The control information was available in the form of both hardcopy documentation and softcopy computer files that duplicated the hardcopy coordinate documentation. The softcopy version enabled the importing of control point reference data into image processing software with minimal opportunities for error.

Table 1 provides scene-specific information for the Landsat TM scenes used in this assessment, including TM path/row identifiers, acquisition dates, the total number of control points available, and the total number of control points used in the validation activity for each scene. *(Note: These test points were used only in this validation and not in Earth Satellite Corporation's orthorectification process.)*

Table 1. Geodetic Control Point Information

Scene Path/Row	Acquisition Date	Number of Control Points Available	Number of Control Points Used
177/75	05/20/89	13	8
177/76	05/20/89	14	9
178/75	05/14/90	17	14
178/76	05/27/89	14	6
179/75	03/21/91	12	9
179/76	05/26/92	12	4
Total		82	50

Procedure

The first step was to process the data using the Ground Control Point (GCP) Editor function available in the ERDAS IMAGINE image processing software. For each scene, the control Point ID, the X-Coordinate (UTM-East), and the Y-Coordinate (UTM-North) were entered into a comma-delimited ASCII file and then imported into the GCP Editor's Point ID, X-Reference, and Y-Reference fields. This action caused ground control point markers to appear on the image displayed in the reference viewer. The resulting image served as a reference dataset for checking geopositional accuracy and for determining approximately where each control point fell within an image. The analyst then used a separate ERDAS IMAGINE viewer to zoom in and to locate the feature associated with a control point on the given Landsat TM scene using a control diagram and descriptive remarks to place the test points in the proper location. This action populated the X-Input and Y-Input fields in the software's GCP editor. If the analyst could not discern the proper location or if the point fell outside the imagery's geographical extent, the point was omitted. The remaining points served as the input.

After selecting the usable control points, the analyst exported an ASCII file that contained the Point IDs, the input coordinates, and the reference coordinates for each scene examined. Because most of the ASCII files contained fewer than 20 test points, and because the Federal Geographic Data Committee recommends a sample size of at least 20 points, the files for individual scenes were combined into one large file. This file provided the input required to execute a Visual Basic program that computes X-differences and Y-differences and that estimates geopositional accuracy. For each point, the Visual Basic program computed the X-differences and Y-differences, the squares of the X-differences and Y-differences, the X-RMSE and Y-RMSE, and the net RMSE (accuracy) using the following accuracy formulas:

$$\mathrm{RMSE}_{\mathrm{X}} = \sqrt{\frac{\sum\left(X_{input} - X_{control}\right)^2}{n}}$$

$$\mathrm{RMSE}_{\mathrm{Y}} = \sqrt{\frac{\sum\left(Y_{input} - Y_{control}\right)^2}{n}}$$

$$\mathrm{RMSE}_{\mathrm{net}} = \sqrt{\left(RMSE_X\right)^2 + \left(RMSE_Y\right)^2}$$

where X_{input}, Y_{input} are the coordinates of the input points; $X_{control}$, $Y_{control}$ are the coordinates of the reference points; and n is the total number of usable control points.

Results

The calculations shown in Appendix B indicate that the RMSE, or net horizontal displacement, of the South Africa GeoCover™ orthorectified TM imagery block is 26.24 meters.

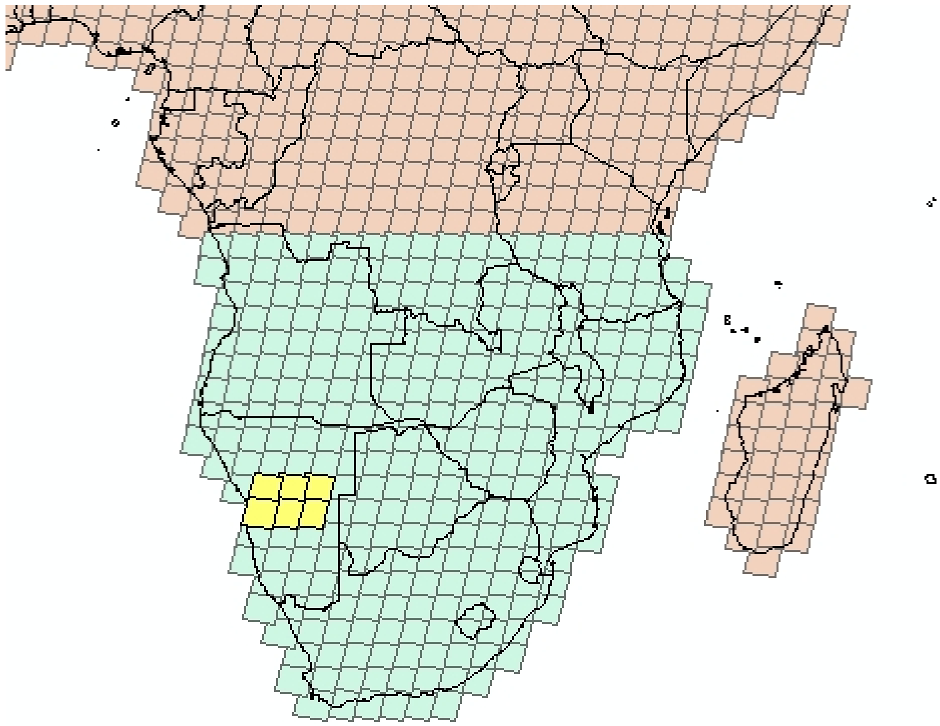
Appendix C provides a cartographic representation showing the locations of the scenes used in validating the South Africa GeoCover orthorectified TM imagery block. This cartographic output, derived from a government-provided, vector-based program, shows overall error within each scene used in the validation via a resultant vector. The resultant vector's length represents the overall magnitude of error. The direction of the resultant vector is the overall direction of error.

Limitations

Sample size and selection of test points were dependent upon the quantity, quality, and utility of the data available. These test points were selected from surplus ground control information that is available only for certain parts of the globe.

The possibility exists for inherent analyst bias because of the variability in image interpretation and pattern recognition capabilities. Final selection of points reflected user subjectivity.

Appendix A



South Africa TM Coverage
Validated scenes appear highlighted in yellow.

Appendix B

Accuracy Computations for South Africa Block GeoCover™
(all measurements in meters)

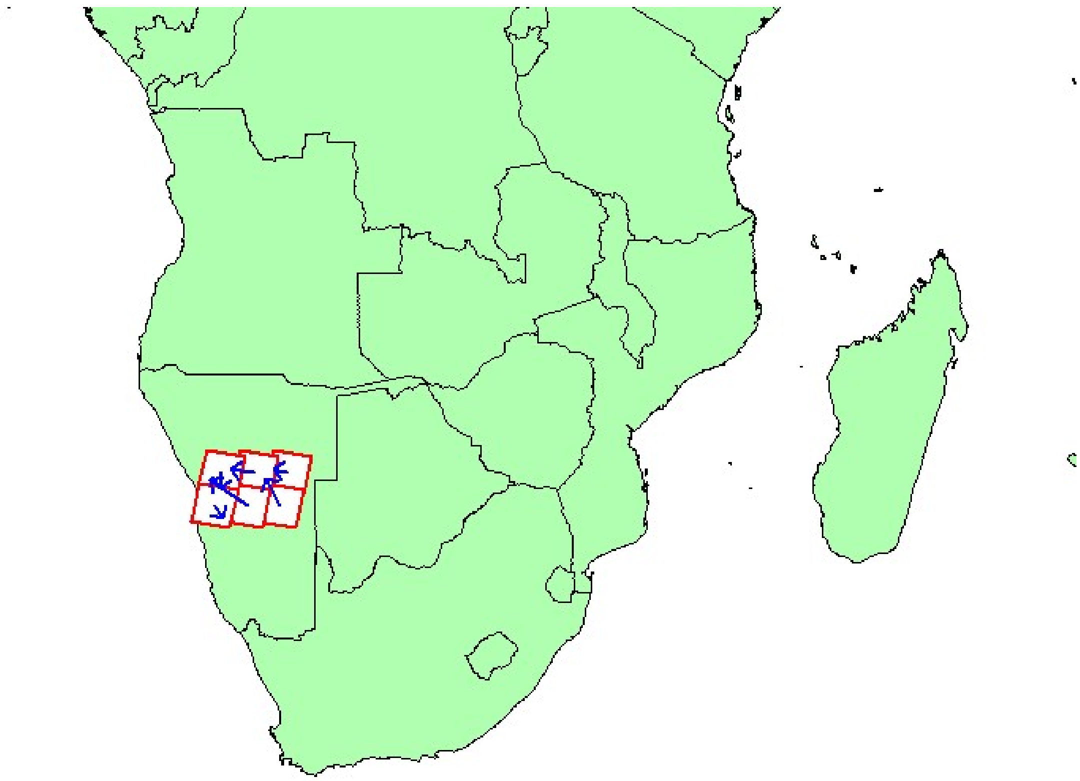
Number	diff in X	squared diff in X	diff in Y	squared diff in Y
17707503	-28.74	825.72	-48.21	2323.72
17707504	5.07	25.75	-1.52	2.31
17707505	29.11	847.33	15.90	252.94
17707507	5.28	27.93	11.41	130.21
17707508	13.10	171.65	11.50	132.34
17707509	-16.03	257.03	-9.07	82.19
17707511	48.32	2335.17	-3.73	13.89
17707512	-1.24	1.54	12.20	148.79
17707510	20.36	414.54	-13.24	175.35
17707511	25.17	633.65	8.76	76.74
17707512	25.08	629.01	-10.32	106.48
17707603	-7.68	59.02	-24.66	608.02
17707604	-14.82	219.67	19.34	374.11
17707605	6.12	37.46	-30.68	941.08
17707606	-8.43	71.08	-29.40	864.12
17707608	23.14	535.58	-24.02	576.77
17807622	-6.33	40.03	-4.90	24.01
17707504	27.60	762.01	5.72	32.66
17707507	-0.16	0.02	8.19	67.06
17707510	18.72	350.48	-4.60	21.14
17807502	23.68	560.65	-7.92	62.65
17807504	14.63	214.10	16.44	270.27
17807505	-8.11	65.78	-2.60	6.75
17807506	12.29	151.09	-6.40	40.93
17807507	22.88	523.49	-0.80	0.63
17807601	-6.40	40.98	12.42	154.21
17907503	8.00	64.04	3.14	9.87
17907506	-2.39	5.70	7.22	52.09
17907509	6.52	42.51	-24.45	597.95
17707520	8.01	64.23	-16.29	265.53
17807602	28.09	788.88	-10.92	119.20
17707601	-13.27	175.97	-6.91	47.75
17707604	3.56	12.64	19.20	368.79
17807603	34.24	1172.64	3.36	11.27
17807604	24.02	577.14	-12.84	164.87
17907603	34.44	1185.80	-39.57	1565.47
17707617	20.22	408.77	-31.75	1008.19
17907502	12.23	149.62	20.01	400.40
17907503	6.96	48.40	9.09	82.72
17907505	7.77	60.40	-2.41	5.79
17907506	5.18	26.79	17.96	322.56
17907507	-14.04	197.16	25.06	628.10
17907508	-3.78	14.31	24.93	621.65

17907509	-19.58	383.45	-31.40	986.15
17907601	0.29	0.09	-24.58	603.93
17907602	14.91	222.39	22.38	501.04
17907607	0.94	0.88	-27.18	738.92
17907608	5.24	27.45	16.62	276.16
17907609	0.08	0.01	-8.18	66.88
17907610	-22.65	512.87	39.28	1542.84

Sum	15942.91	Sum	18477.51
Average	318.86	Average	369.55
RMSEx	17.86	RMSEy	19.22

$RMSE_{net}$ 26.24 meters.

Appendix C



South Africa Vector Diagram